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Physical activity in people with PTSD: a systematic review of correlates

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Abstract

Background: People with posttraumatic stress disorder (PTSD) are more likely than the general population to be physically inactive. The present review systematically evaluated correlates of physical activity across the socio-ecological model for people with PTSD. *Methods:* Two independent reviewers searched Embase, PubMed, PsycARTICLES and CINAHL from inception until June 2015, combining the medical subject heading 'post-traumatic stress disorder' or 'PTSD', with 'physical activity' or 'exercise'. Data were extracted by the same independent researchers and summarized according to the socio-ecological model.

Results: Eight papers involving 1,368 (994♂) participants (age range=18-70years) were eligible and enabled evaluation of 21 correlates. The only correlate consistently (n≥4) associated with lower physical activity participation in persons with PTSD were symptoms of hyperarousal. No consistent facilitators were identified. *Conclusions:* Hyperarousal symptoms are associated with lower physical activity participation among people with PTSD and should be considered in the design and delivery of individualized exercise programs targeting this population. The role of social, environmental and policy factors on physical activity participation among people with PTSD is unknown and should be addressed by future research.

Keywords: physical activity; exercise; post traumatic stress disorders

Introduction

People with posttraumatic stress disorder (PTSD) experience an excess mortality rate two to three times higher than the general population[1,2]. Previous research demonstrated that the presence and severity of PTSD is associated with the presence and severity of cardiovascular diseases (CVD)[3] and predicts mortality independent of age, gender, and other conventional risk factors[3]. The pathophysiology underlying the association between PTSD and increased risk for CVD is complex and yet to be fully elucidated[4]. Emerging evidence suggests that both share common pathophysiological features, including hypothalamic-pituitary-adrenal (HPA) and sympatho-adrenomedullary dysfunction[5], inflammation[6], and common genetic links and epigenetic interactions[7]. In addition, cumulative long-term effects of poor health behaviors place people with PTSD at greater risk of cardio-metabolic diseases[8]. People with PTSD are more likely than the general population to have unhealthy lifestyle behaviors, including high rates of sedentary behavior[9], smoking[10], alcohol and substance abuse[11], and unhealthy eating habits, i.e. diets high in saturated fats and refined sugars[12] and low in fruit[13]. In a recent review, Hall et al.[14] found that the current literature regarding physical activity in people with PTSD is inconsistent, with more or less half of the identified studies reporting a significant negative association between PTSD and physical activity participation and the other half reporting no significant associations between PTSD and physical activity at all.

PTSD is characterized by symptoms of hyper-arousal, re-experiencing and avoidance[15]. PTSD symptoms are commonly treated with a combination of both pharmacological and non-pharmacological therapies including selective serotonin reuptake inhibitors[16], off-label use of atypical antipsychotics[17], off-label use of benzodiazepines[18], and psychological therapies, including trauma-focused cognitive-behavioural therapy, eye movement desensitisation and reprocessing, stress management

and group cognitive-behavioural therapy[19]. However psychotropic medication may have adverse cardio-metabolic side effects[20]. Psychological treatments are generally free from side-effects but some people may decline psychological therapy due to low expectations of positive outcome or perceived stigma[21]. In recent years, research has demonstrated that adequate physical activity may promote mental and physical health in persons with PTSD[22-24]. Despite the increasing body of evidence demonstrating the beneficial effects associated with physical activity participation, many people with PTSD remain physically inactive[25]. Thus, there is a need for research to investigate factors that influence physical activity participation in this group[14], which may have an integral role in reducing the burden of CVD and improve health and wellbeing. Specifically, research is required to explore the amount (e.g., frequency, intensity, duration) and types of physical activity (e.g., structured exercise versus lifestyle physical activity) needed for the observed mental and physical health benefits in people with PTSD. However, in order for physical activity interventions to be effective in promoting mental and physical health, it is important to address barriers and promote factors that enable participation.

Understanding barriers and facilitators of participation in physical activity in people with PTSD is an essential first step toward the development and implementation of effective treatments. Behavioral theories, such as the social-ecological model[26], are useful in attempting to understand barriers and promoting facilitators. Social-ecological models suggest that multiple relevant attributes influence health behavior. These include intrapersonal (demographic, biological, psychological, emotional and cognitive), interpersonal/cultural (e.g., social support), physical environment (e.g., distance to the facilities, financial costs, enjoyable scenery), and policy (laws, rules, regulations, codes) factors[26]. Various intrapersonal, interpersonal, physical environment and policy-related variables have demonstrated strong positive associations with physical activity in the

general population[27]and in people with severe mental illness[28-32]. Correlates consistently associated with physical activity participation in the general population are male gender, a higher self-efficacy, physical activity history, the current health status and the intention to be physically active[27]. Little is however known about whether these factors demonstrate similar relationships with physical activity behavior among people with PTSD. A qualitative study[33] reported that among people with PTSD a lack of time (14% before and 39% after PTSD onset) and lack of motivation (24% before and 71% after PTSD onset) negatively affected physical activity participation. Quantitative research may identify potential mediators and moderators of physical activity that can be targeted by future interventions. The present review aimed to systematically evaluate published quantitative studies of correlates of physical activity in persons with PTSD. In addition to summarizing methods and results of these studies, gaps in the literature were identified and directions for future research are proposed.

Methods

Data sources and searches

Two independent reviewers (DV and SR) performed an electronic search of Embase, PubMed, PsycARTICLES and CINAHL from the inception of these databases to June, 2015. Keywords used were 'physical activity' or 'exercise' and 'post traumatic stress disorder' or 'PTSD' in the title, abstract or index term fields. Manual searches were also conducted, using reference lists from identified articles.

Eligibility criteria

Inclusion criteria were as follows: (a) clinician confirmed or self-reported PTSD according to pre-determined criteria, (b) studies contained quantitative research and had been published in a peer-reviewed journal, (c) the dependent variable was a measure of physical activity participation. Studies could use a variety of physical activity measures reflecting a range of intensities. For cohort or intervention studies, only associations with baseline data were included. Authors were contacted to provide additional data on associations of baseline characteristics if these were not available in the identified publications.

Articles were excluded if the dependent variable was aerobic fitness, physical activity intention, self-efficacy, or other intermediate (non-behavioral) measures because these variables are less direct indicators of actual physical activity participation. Reviews, case-reports, conference abstracts and expert opinions were excluded. If study data were based on different diagnoses, the first or corresponding author was asked to send results from additional analyses regarding the target group.

Data collection

Two reviewers independently extracted data from the included studies using a predetermined form. The data extracted from each study included: (a) gender, (b) age, (c) ethnicity, (d) setting if applicable, (e) criteria used for the PTSD diagnosis, and (f) physical activity assessment tool, and (g) study design. In accordance with previous reviews[27-32] the following categories were used to code the quality of the physical activity measure: (a) self-report with poor, unknown or undefined reliability/validity, (b) self-report with described and acceptable reliability/validity, and (c) acceptable objective measurements. Following Warren et al.[34], objective measurements included motion sensors, such as accelerometers and pedometers, combined heart rate and accelerometer devices and the doubly labeled water method. The acceptability of the psychometric properties was assessed following De Von et al.[35]. Variables were classified as "related" or "not related" to physical activity based on statistical significance, and the direction of association for related variables was coded. The detailed data tables were further analyzed to create tables that summarized the state of the literature on different variables.

Selection and categorization of variables.

We selected and categorized physical activity correlates into the following categories: (a) demographic, (b) biological, (c) psychological/cognitive/emotional, (d) behavioral attributes/skills, (e) social/cultural factors, (f) physical environment, and (g) policy factors. When studies based on the same sample examined the same correlates, only the most recent data and/or those based on the largest sample size were included. The socio-ecological approach aims to identify the domains which have been explored in the literature and to elucidate the multidimensional perspective of potential influences on the physical activity behavior in people with PTSD.

Coding associations with physical activity

A variety of statistical techniques were used to evaluate correlates, most commonly uni-/bivariate analyses, including correlations, t-tests, and ANOVA. If both uni-/bivariate and multivariate tests were conducted, uni-/bivariate tests were reported for consistency across studies. The column "related to physical activity" indicated studies reporting significant associations between the variable and the physical activity measure. The direction of association is indicated with a "+" or "-" The column "unrelated to physical activity" indicates which studies reported non-significant associations between the variable and physical activity.

Coding of analyses

Numbers in the columns refer to the numbers in the online supplement. If analyses were conducted separately for male and female subjects, "M" or "F" is indicated. Due to the small number of studies reporting analyses specific to ethnic or socio-economic groups, these subgroup analyses were not included in the summary tables.

Summary codes

As many of the identified articles did not report correlation values and the methodology of included studies varied considerably, a formal meta-analysis of correlates was not conducted. Summary codes were presented and calculated for each variable explored in accordance with the method of Sallis et al[36]. We summarized how many studies supported an association or not and in which direction. Data were presented as percentages which will refer to the number of associations supporting the expected association, divided by the total number of associations for the variable. Associations were also coded with: "0" (0-33% of studies supporting association); "?" (34%-59% of

studies supporting an association); or "+" or "-" (60%-100% of studies supporting an association). When four or more studies supported an association or no association, it was coded as "00", "--", or "++" indicating that there is consistent evidence for that correlate. The "??" code indicated a variable that was investigated four or more times studied with considerable lack of consistency in the findings.

Statistical analyses

Fisher's exact tests were used to examine differences in proportions of significant associations between (a) physical activity assessment tools with known and acceptable validity compared to those with unknown or non-reported psychometric properties, (b) subjective and objective physical activity assessment tools, (c) studies with a sample size below or equal to or higher than the median sample size of the identified studies, and (d) studies including patients with a formal diagnosis versus studies including patients with self-reported PTSD symptoms. The significance level was set at $p<0.05$.

Results

Out of 23 potentially eligible studies, eight[24,37-43] were included in this review. Reasons for exclusion are shown in Figure 1. None of the three research groups contacted provided us with additional, unpublished correlation analyses for our target group or full-texts. In two studies[40,43] there was an overlap in correlates investigated in the same sample. In this case only the data from the largest study[44] were included.

[Insert Figure 1 about here]

Across all studies, a total of 1,368 (994♂) persons with PTSD (age range=18-70years) were included in the analyses. In one study PTSD was assessed by self-reported symptom scales, while eight studies involved participants with an additional physician/clinician diagnosis using a structured clinical diagnostic interview. Seven studies were based on cross-sectional data or baseline data from interventional studies while only one study[43] had a longitudinal design.

Concerning the quality of the physical activity measure, eight studies utilized un-validated self-reports or self-reports without reported psychometric properties, and only one study[24] used a PA measure that has good psychometric properties. No study used objective measures. A greater number of associations were reported in the study using physical activity assessment tools with known and acceptable validity compared to the studies using tools with unknown or not acceptable psychometric properties. The proportion of significant correlates in studies with a sample size lower than or equal to the median sample size was not significantly different to those with a sample size higher than the median($p=0.21$). Table 1 presents the characteristics of the included participants, the quality of physical activity assessment and statistical analyses performed. Table 2 summarizes the correlates of physical activity participation.

[Insert Table 1 about here]

[Insert Table 2 about here]

Demographic correlates. Five demographic correlates (age, gender, ethnicity, education, marital status) were evaluated in the literature and none were consistently associated with physical activity participation (Table 2). There was consistent (n≥4) evidence that older age was not a barrier.

Biological correlates. Three biological correlates (body mass index, waist circumference and the presence of fibromyalgia) were studied. Only the presence of fibromyalgia was associated with less physical activity participation (n=1) (see Table 2).

Behavioral attributes/skills. Two correlates (smoking status and sleep quality) were examined within the behavioral attributes and skills part of the model. A better sleep quality was associated with higher physical activity levels. Smoking status was only investigated in one study and was found to be unrelated to the level of physical activity (see Table 2).

Psychological, cognitive and emotional correlates. Out of 11 psychological, cognitive and emotional variables (see Table 2), two consistently significant associations with physical activity participation was reported. While there is still some uncertainty regarding depressive symptoms, there was strong consistent evidence (n≥4) that PTSD symptom severity and in particular hyper-arousal as a specific symptom was a negative correlate of physical activity participation.

Social/cultural factors and the physical environment. No studies investigated the role of the social and the physical environment.

Policy factors. No policy-level correlates were found.

Discussion

General findings

To the authors' best knowledge, the present review is the first to investigate correlates of physical activity in people with PTSD. The most consistent correlates of lower physical activity were symptoms of hyper-arousal. At the biological and behavioral level, no consistent correlates were found, and no data were available at all regarding social, physical environment or policy level correlates. This lack of consistent correlates in these domains might be due to (a) the paucity of studied correlates, and (b) differences in study design, sample characteristics, choice of assessments/correlates and analysis methods.

Knowledge about correlates of physical activity behavior helps identifying high-risk persons in whom physical activity participation is reduced, in addition to those who are less likely to engage in physical activity and therefore require more intense and targeted interventions. Addressing barriers through tailored and integrated physical activity programs have the potential to improve long-term physical health trajectories. This is particularly pertinent given recent data indicating that many people with PTSD highly value, are preparing for and feel ready to engage in healthier lifestyles.[44]

When looking at the current evidence on demographical correlates of physical activity participation in people with PTSD, older age and female gender, two demographic variables found to be consistently associated with lower physical activity participation in the general population[27,36] were not found to be associated with physical activity behavior in PTSD. Gender data were however conflicting and warrant more research. The current findings should be encouraging to healthcare professionals, as it suggests that persons with PTSD can be expected to participate in some form of physical activity across the lifespan.

More research on biological physical activity barriers is needed. It has been suggested that co-morbid somatic conditions may limit mobility and/or result in more pain during physical activity in people with mental illness[29-31], but this has not been explored sufficiently in people with PTSD. However, our review indicates that the presence of chronic somatic conditions, such as fibromyalgia, which are often comorbid among individuals who have been exposed to extreme life events[45], are potentially important barriers that should be considered by health care professionals and researchers when developing physical activity programs.

The presence of hyper-arousal symptoms was identified as the most consistently reported barrier for physical activity participation. It is possible that the observed inverse associations between physical activity participation and hyper-arousal symptoms were due to the lower likelihood of more anxious individuals to engage in physical activity. Patients with an increased trait/state anxiety, for example, might fear that engagement in physical activity will provoke physiological reactions such as hyperventilation, tachycardia, dizziness, or sweating, all reactions that can be associated with signs and symptoms of panic[46]. Alternatively, because physical activity has been demonstrated to have anxiolytic effects in anxious patients via repeated exposure to anxiety-related somatic sensations when being physically active[46], it is possible that increased physical activity among patients with PTSD leads to decreased hyper-arousal symptoms. Clinically, it could be hypothesized that exposing patients with PTSD to the physiological symptoms they fear, such as rapid heart rate, in the context of physical activity increases tolerance for such symptoms. This repeated exposure may reinforce that the feared physiological sensations may be uncomfortable, but do not pose a serious threat and consequently could facilitate habituation. Due to the current focus on correlates, it was however not possible to determine directionality of effects. In the same

316 way we were not able to explore in greater detail the directionality of effects between the
317 sleep quality and physical activity participation. A poorer sleep quality might be
318 associated with higher fatigue and thus less physical activity engagement[44,47], or
319 participation in physical activity may result in improved sleep quality[48]. Clinically, the
320 findings from the present review suggest that sleep is a behavioral factor that should be
321 assessed and potentially targeted in physical activity interventions for patients with
322 PTSD. For example, sleep problems could affect a patient's willingness or ability to
323 implement physical activity behavioral interventions, while sleep improvements might
324 encourage physical activity participation. Additionally, sleep quality might influence
325 physical activity quality, such as effort expended during physical activity or duration
326 patients are engaged.[41] Further research is needed to assess possible sleep-physical
327 activity behavioral linkages.
328
329 *Limitations and future research*
330 There are several limitations to this review, which should be acknowledged. First of all,
331 the diversity of physical activity measures, subject samples and analysis strategies
332 prevented us from performing a formal meta-analysis. Measuring physical activity levels
333 poses many challenges. Self-report questionnaires are known to require motivation to
334 complete all of the questions, and it is often difficult to ascertain the frequency, duration
335 and intensity of physical activity with good reliability, while more objective devices such
336 as accelerometers and pedometers are considered to offer more precise estimates of
337 physical activity and remove many of the issues of recall and response bias associated
338 with self-report measures[34]. However, a previous feasibility study[49] demonstrated that
339 inpatients with PTSD showed poor compliance with wearing objective devices.
340 Contributing factors to poor compliance may include a lack of motivation and fatigue[49].

Only one study used a validated questionnaire[23]. The International Physical Activity - Short Form[50] previously demonstrated sufficient validity in people with PTSD[49] although in this study more than 15% of the cases were excluded from the analyses due to erroneously high values. The authors stated that it is possible that participants may have reported physical activity based on their memory of pre-trauma levels of participation, in which physical activity and regular exercise would have been required (e.g. in first-responder emergency crews). One of the most important challenges in physical activity research in people with PTSD therefore is producing a low cost, easy to use, reliable and valid physical activity questionnaire that captures current sedentary behaviors and physical activity participation for the entire physical activity continuum (from low to high intensity).

A second limitation of the current review is that most correlates of physical activity were only documented in a small number of studies. Examination of the same, standardized variables in different studies is therefore necessary in order to build a body of evidence that can support or refute the potential influence of individual variables.

Thirdly, the physical activity correlates literature in people with PTSD is still predominantly based on cross-sectional studies, precluding the ability to infer causal relationships between the hypothesized correlates and physical activity. Accordingly, in order to further understanding of the relationship between PTSD and physical activity, we echo recent calls[14] for further longitudinal and intervention studies to confirm the relationship between PTSD and physical activity.

A fourth limitation is that the majority of the studies considered physical activity correlates at only one level in the social-ecological model. Future studies should attempt to analyze the role of multiple correlates of physical activity from a social-ecological perspective. For example, various physical activity correlates have been identified at

different levels of the social-ecological model[26], yet no research has examined how these correlates interact to explain physical activity behavior in PTSD.

Future research should not only focus on the identified variables, but also on those that remain under-studied e.g., the amount and type of social support necessary to begin and maintain physical activity behavior in persons with PTSD. Future research could explore whether: (a) the relationship between physical activity participation and professional support is a dynamic process in which the sources of support or need for support change over time, and (b) any social barriers can be identified and addressed by involving others in the rehabilitation process. Some of these interpersonal factors have been previously examined in the general population, but not for people experiencing mental illness[51-53]. The establishment of relationships between the physical environment and physical activity levels in turn, may prove useful from a community planning or policy perspective. To date, no policy-level correlates were identified. Correlates at this level of the social-ecological model may be explored however best using a qualitative approach[54]. Researchers should examine, which policies are currently in place. Interviews of people with PTSD and their healthcare professionals may provide further insight as to what is needed to promote an active lifestyle. Future studies should also evaluate environmental modifications, which can provide an opportunity to examine changes in physical activity levels occurring in conjunction with changes in the physical environment. If the purpose of this kind of physical activity research is to inform and motivate policy changes that will improve the mental and physical health of persons with PTSD, merely documenting the relationship between environmental variables and physical activity will not meet this requirement. At some point, environmental and policy change research will need to include assessments of broader health outcomes, such as

changes in the prevalence of chronic co-morbidities, physical activity service utilization, as well as the economic costs and benefits of proposed policy changes.

In conclusion, the present review demonstrated that hyper-arousal symptoms are the most consistent negative correlates for physical activity participation in people with PTSD identified in the literature to date. As such, these symptoms must be considered in the design and delivery of physical activity programs for people with PTSD. Because physical activity can expose people experiencing PTSD to many of the bodily sensations that are feared by individuals with PTSD (e.g., increased heart rate, increased perspiration, elevated respiration rate), physical activity can be viewed as a vehicle for interoceptive exposure which may facilitate habituation to the feared sensations

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Declaration of interest

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Figure 1. Flow chart of the inclusions and exclusions

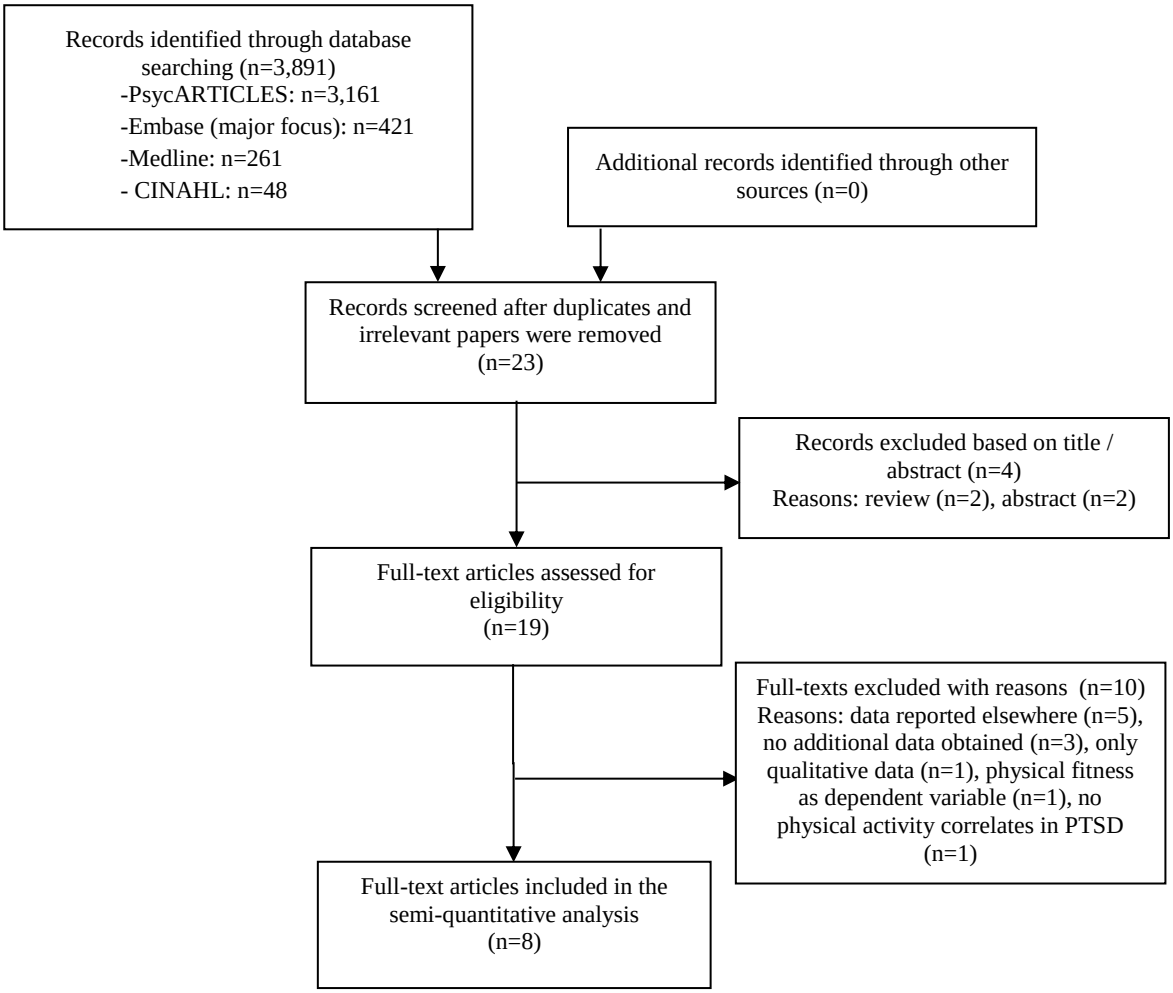

Table 1. Study characteristics

First author / year	Study design	Participants	PTSD diagnosis criteria	PA instrument	Quality of PA measurement	Statistical tests
Arnson 2007[37]	Cross-sectional	55♂ with fibromyalgia; 18-60 yrs	DSM-IV; Clinician Administered PTSD Scale	Do you exercise often, occasionally or not at all?	A	ANOVA
Rutter 2007[38]	Cross-sectional	200 (75♂) undergraduate students; 18-23yrs; 59.8% Caucasians	PTSD Checklist Civilian Version	On the average, how many times per week do you engage in physical activity, exercise or work which increases the heart rate, causes you to breathe and sweat heavily, and is done for at least 20 minutes in duration?	A	bivariate correlations
Davidson 2013[39]	Cross-sectional	346 (280♂) veterans in a 90days rehabilitation program; 45.4±14.3yrs; 54.5% Caucasians	DSM-IV; PTSD Checklist Military Version	Over the past month, how often have you engaged in regular activities (e.g., brisk walking, jogging, bicycling) long enough to work up a sweat?	A	zero-order correlations
Vujanovic 2013[40]	Cross-sectional	81 (36♂) community recruited; 24.3±10.5yrs; 89.5% Caucasians	DSM-IV; Posttraumatic Diagnostic Scale	Exercise Habits Questionnaire–Revised	A	zero-order correlations
Talbot 2014[41]	Baseline data of a prospective cohort study	258 (230♂) veterans; 59% Caucasians	DSM-IV; Clinician Administered PTSD Scale	Which of the following statements best describes how physically active you have been during the last month (doing activities such as 15 to 20 min brisk walking, swimming, general conditioning, or recreational sports): 1-2/month, 3-4/month, 1-2 /week, 3-4/week, or 5+/week	A	Hierarchical multiple regression models
Babson 2015[42]	Intervention: longitudinal data	247♂ veterans in a 60-90days rehabilitation program; 24-70yrs; 60.9% Caucasians	DSM-IV; PTSD Checklist Military Version	Total number of days cycled	A	zero-order correlations
Harte 2015[43]	Baseline data	108 (63♂) community recruited; 18-62yrs; 91.7% Caucasians	DSM-IV; Posttraumatic	Exercise Habits Questionnaire–Revised	A	zero-order correlations

	intervention study		Diagnostic Scale			
Rosenbaum 2014[24]	Baseline data intervention study	76(63♂) inpatients; 47.6±11.9yrs	DSM-IV; PTSD Checklist Civilian Version	International Physical Activity Questionnaire- Short Form	B	Pearson's correlations

A=self-report of poor or unknown reliability/validity for patients with PTSD, B=self-report with acceptable reliability/validity for patients with PTSD, and C=acceptable objective measure (pedometers, accelerometry), PA=physical activity, ANOVA=analysis of variance.

Table 2. Summary of studies of determinants of physical activity in patients with PTSD

Determinant variable	Related to PA		Unrelated to PA	Summary code°	
	Study*	Assoc.	Study*	Assoc.	% studies reporting assoc.
Demographic					
Age (older)			24; 37; 41; 43	00	0% (0/4)
Gender (female)	44	-	41	?	50% (1/2)
Race (White)			43	0	0% (0/1)
Education (higher)			43	0	0% (0/1)
Marital status (married)			43	0	0% (0/1)
Biological					
Body mass index (higher)			41	0	0% (0/1)
Waist circumference (higher)			24	0	0% (0/1)
Fibromyalgia (presence)	37	-		-	100% (1/1)
B*ehavioral attributes /skills*					
Smoking status (+10cig / day)			42	0	0% (0/1)
Sleep quality (better)	24; 39; 41	+	42	+	75% (3/4)
Psychological, cognitive and emotional					
PTSD symptoms (higher)	24; 38; 41	-	37; 39	-	60% (3/5)
PTSD re-experiencing (higher)	24	-	38; 42; 43	0	25% (1/4)
PTSD avoidance (higher)	24	-	38; 42; 43	0	25% (1/4)
PTSD hyperarousal (higher)	23; 38; 42; 43	-		--	100% (4/4)
Clinical global impression (score)			37	0	0% (0/1)
Physical quality of life (better)	37	+		+	100% (1/1)
Mental quality of life (better)	37	+		+	100% (1/1)
Depression (higher)	24; 38	-	39; 41	??	50% (2/4)
Anxiety (higher)	24	-		-	100% (1/1)
Suicide ideation (present)	39	-		-	100% (1/1)
Number of traumas (n)			43	0	0% (0/1)

PA=physical activity; *Reference numbers; °The percentages in parentheses refer to the number of associations supporting the expected association divided by the total number of associations for the variable. Associations are coded with: "0" (0-33% of studies supporting association); "?" (34%-59% of studies supporting an association); or "+" or "-" (60%-100% of studies supporting an association). When four or more studies support an association or no association, it is coded as "00", "--", or "++" indicating

that there is consistent evidence for that correlate. The “??” code indicates a variable that was investigated four or more times studied with considerable lack of consistency in the findings.